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Effect of vacuum packaging on storage stability of osmotic dehydrated coconut

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Abstract
Sugar solution was used as osmotic agents for the processing of osmotic dehydrated coconut and packed in aerobic and vacuum condition. The free fatty acid content of aerobic packaged dehydrated coconuts T_0, T_1, and T_3 were between the range of 0.410 to 1.186, 0.404 to 0.564 and 0.394 to 0.523 per cent, respectively, whereas the value of vacuum packaged samples were ranged between 0.410 to 1.141, 0.404 to 0.538 and 0.394 to 0.498 per cent. Initially T_0, T_1 and T_2 contained 4.52, 4.45 and 4.38 per cent of peroxide value, respectively. At the end of the storage, the values were increased between the range of 8.34 to 7.46 (control), 5.79 to 5.32 (T_1) and 5.19 to 5.07 (T_2) per cent. The samples T_1 and T_2 initially had 4.0 x 10^6/g of bacteria which showed an increase of 6.0 and 5.0 x 10^6/g the end of the storage.

Keywords: Coconut, vacuum, dehydration, aerobic, storage

Introduction
Dehydrated coconut is the edible, dried-out shredded coconut meat prepared from fresh kernel of fully matured coconut. Dehydrated coconut is the most important processed product of coconut and its annual production is estimated as 10,000 metric tonnes[10]. Annual export of desiccated coconut from India is1638.18 metric tonnes which worth of 1419.69 lakhs rupees[15]. It is used both in household foods and processed foods particularly in ready-to-cook mixes and in packaged and canned foods. In the bakery and confectionery industry desiccated coconut is a favoured ingredient[5]. The osmotic dehydration is a method for the partial dehydration of foods by immersing them in a concentrated sugar or salt solution. Osmotic dehydration is done to improve colour and flavour, to reduce shrinkage of the food material and potential energy savings up to 50% of initial moisture is removed from the food material without undergoing a phase change[7]. The fat content of the desiccated coconut is easily oxidised either by lipase or by the enzymes of microbes during storage. The chain of actions such as oxidation of fatty acids, release of free fatty acids contributed to the development of rancidity and off-flavour in the coconut based products. The oxidation of fatty acids can be prevent by excluding oxygen from the product. Vacuum packing is a method of packaging that removes air from the package prior to sealing. Vacuum packaging of food materials helps in preserving the quality of packed products. The main objective of vacuum packaging is to deplete the oxygen content in the package. Due to the lack of oxygen, the aerobic microorganisms gets reduced in number which is the cause of spoilage in majority of the food products. The occurrence of spoilage due to the oxidation is also reduced[10]. Hence, the study was undertaken to study the effect of vacuum packaging on physico chemical changes during the storage of osmotic dehydrated coconut.

Methods and materials
Processing of osmotic dehydrated coconut
The process involved in the preparation of osmotic dehydrated coconut are preparation of sample, Preparation of osmotic agents, Osmosis of coconut scrapings and dehydration (Fig.1). The selected coconuts were broken into two halves and scraped by using a stainless steel scraper (without testa). The scraped uniform size coconut was selected and steam blanched for 10 min. Sugar solution containing 10 and 20^o brix were prepared. For the preparation of sugar solution, desired quantity of sugar was taken in a sterilized vessel and distilled water was added and boiled to make up correct concentration.

The solution was filtered through a clean muslin cloth and cooled. The coconut scrapings and sugar solution were taken in the ratio of 1:2. The blanched coconut scrapings were soaked individually in glass bottles in sugar solutions. To preserve the colour and to prevent the spoilage of coconut samples 250 ppm of SO_2 was added to the soak solution and kept for 24 hours. After osmosis, the solution was drained out from the coconut scrapings and dried separately in the mechanical dryer at 60° C for 4 to 5 hr (up to 4.0 % moisture). Each dried sample was cooled immediately.

Packaging and Storage studies

The dehydrated coconut samples were prepared in a large scale and packed individually in food grade polyethylene bags (300 gauge thickness) with two packaging methods i.e. aerobic and vacuum packaging and were kept in room temperature to study the storage behaviours. The changes in the physico chemical characteristics were analysed once in 30 days during the storage period (6 months).

Physico - Chemical analysis of *Jhol*

Free fat acid value was expressed as mg of potassium hydroxide required to neutralize free fatty acids of 100 g sample[1]. The pH was determined with the help of pH meter calibrated with the standard buffer solutions. The titrable acidity was calculated by titrate the samples against 0.1 N sodium hydroxide by using phenolphthalein as indicator[1]. Moisture content was determined by weight loss of 5 g sample after heating at 110°C for 2 hours[1]. The ash content was measured by weight loss of 5 g of moisture free sample for heating at 550° C for 5 hours[1]. The crude fat content in the samples was determined by ether extraction using glass soxhlet. The crude protein was determined by using Micro Kjeldhal method. Sugar content in the samples was determined by using Lane - Eynon method[1]. Calcium, Iron and phosphorus were determined by using flame photometer[8].

Microbial load

The microbial load of osmotic dehydrated coconut samples were enumerated by serial dilution method. The samples were serially diluted. Dilution of 10^{-2}, 10^{-3} and 10^{-6} were taken for all the analysis. One ml of the serial dilutions of the samples were taken in the petri dishes and appropriate media was added for the specific organism. The plates were incubated at room temperature for 48 h for bacteria, 3 days for fungi and actinomycetes and the colonies were counted[2].

Statistical analysis

The analysis of variance of the data obtained was done by using Completely Randomized Design (CRD). Critical differences were worked out at 5% probability level and presented[9].

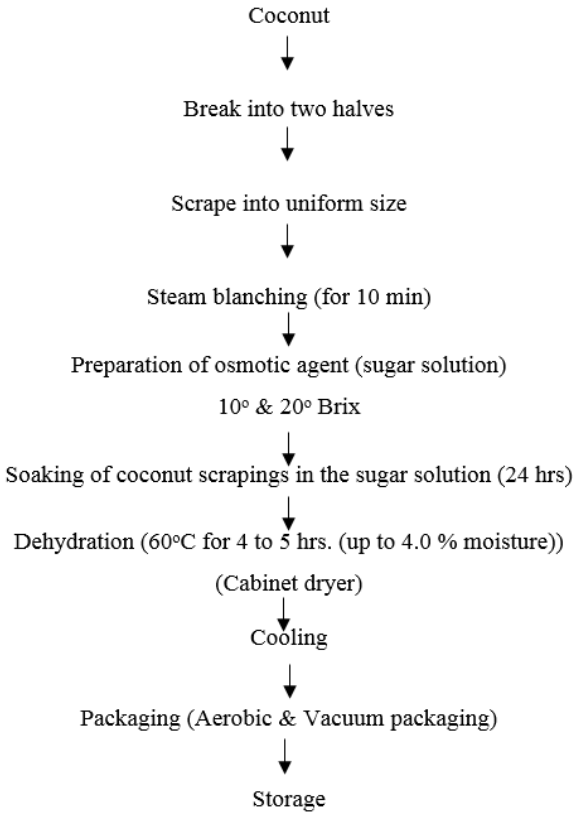

Fig 1: Flow chart for the processing of osmotic dehyrated coconut

Result and discussion

The aerobic and vacuum packaged osmotic dehydrated coconut were evaluated for their storage stability. The changes in moisture, total sugar, reducing sugar, free fatty acid, peroxide value and microbial population were analysed.

Moisture content

A gradual increase in the moisture contents of the samples were noted in both the storage conditions irrespective of treatment and packaging methods (table 1). The control sample had slightly higher moisture content before and after storage than T_1 and T_2. The moisture content of aerobic packaged dehydrated coconuts T_0, T_1, and T_3 were between the range of 4.22 to 5.98, 4.18- 5.44 and 4.14 to 5.49 per cent, respectively, whereas the value of vacuum packaged samples were ranged between 4.22 to 5.50, 4.18 to 5.17 and 4.14 to 5.30 per cent, respectively. The amount of increment in moisture content during storage of vacuum packaged

dehydrated samples are lower than the aerobic packaged samples.

A significant difference in the moisture content of the dehydrated coconut samples was noted between the treatments, packaging materials and storage period. Vennila and Pappiah (1998) [14] found that the stored osmotically dehydrated coconut showed an increase in the moisture content between O and 90 days of storage. Similar increase in the moisture content was observed in the control as well as in the treated samples.

Table 1: Changes in moisture (%) content of osmotic dehydrated coconut during storage

Storage period (days)	Control (T_0)		Treatments			
			10° Brix (T_1)		20° Brix (T_2)	
	Aerobic (P_1)	Vacuum (P_2)	Aerobic (P_1)	Vacuum (P_2)	Aerobic (P_1)	Vacuum (P_2)
0	4.22	4.22	4.18	4.18	4.14	4.14
30	4.41	4.35	4.28	4.23	4.25	4.22
60	4.74	4.51	4.50	4.36	4.46	4.39
90	4.93	4.73	4.71	4.50	4.70	4.55
120	5.15	4.87	4.95	4.76	4.98	4.84
150	5.40	4.99	5.18	4.92	5.25	4.96
180	5.98	5.50	5.44	5.17	5.49	5.30

CD ($P \leq 0.05$) Between Treatment (T) = 0.037, Packaging method (P) = 0.030, (T X P) = 0.052, Storage period (S) = 0.057, (T X S) = 0.098, (P X S) = 0.080 and T X P X S= Non-significant (N.S)

Total sugar

The total sugar content of control was lesser than the treated samples throughout the study period (table 2). The sample treated with 20°Bx had maintained higher concentration of total sugar than the sample treated with 10°Bx between 0 and 180 days of storage. A gradual reduction in the total sugar content was noted in all the samples irrespective of packaging methods and treatments. Initially T_0, T_1 and T_2 contained 8.00, 10.58 and 11.93 per cent of total sugar, respectively. At the end of the storage, the values were between the range of 5.03 to 5.27 (control), 8.17 to 8.69 (T_1) and 9.95 to 10.04 (T_2) per cent. This study revealed that reduction in total sugar content during storage is lower in vacuum packaged samples than the aerobic packaged samples. The statistical analysis of the data revealed a significant difference in the total sugar content of dehydrated coconut among various treatments, packaging methods and storage period.

Vennila and Pappiah (1998) [14] stated that the total sugar content of control and treated coconut pieces had reduced from 8.35 to 5.70 and from 10.88 to 10.05 per cent respectively after 90 days of storage. The reduction noted in the total sugar content of the control resembled similar to the values reported by Vennila and Pappiah (1998) [14].

Table 2: Changes in total sugar (%) content of osmotic dehydrated coconut during storage

Storage period (days)	Control (T_0)		Treatments			
			10° Brix (T_1)		20° Brix (T_2)	
	Aerobic (P_1)	Vacuum (P_2)	Aerobic (P_1)	Vacuum (P_2)	Aerobic (P_1)	Vacuum (P_2)
0	8.00	8.00	10.58	10.58	11.93	11.93
30	7.71	7.84	10.24	10.39	11.51	11.74
60	7.35	7.38	10.08	10.20	11.20	11.45
90	6.29	6.46	9.65	9.91	10.96	11.13
120	5.95	6.04	9.14	9.53	10.40	10.83
150	5.57	5.68	8.50	9.17	10.17	10.45
180	5.03	5.27	8.17	8.69	9.95	10.04

CD ($P \leq 0.05$) Between Treatment (T) = 0.058, Packaging method (P) = 0.047, (T X P) = 0.082, Storage period (S) = 0.088, (T X S) = 0.153, (P X S) = 0.125and (T X P X S) = N.S

Reducing sugar

The conversion of total sugar into simple sugar might have increased the reducing sugar content of stored osmotic dehydrated coconut (table 3). As the storage period increases, the reducing sugar content had also increased in all the samples irrespective of packaging methods and treatments. Similar to total sugar content, the control sample exhibited lesser reducing sugar content throughout the study period than T_1 and T_2. Initially T_0, T_1 and T_2 had 4.40, 7.05 and 7.88 per cent of reducing sugar, respectively. The corresponding values at the end of storage for control ranged between 7.14 and 6.27, 10.15 and 9.76 for T_1 and 10.44 and 10.35 per cent of reducing sugar for T_2 packed in aerobic and vacuum condition. The amount of increase in reducing sugar content of the aerobic packaged samples are higher than the vacuum packaged osmotic dehydrated coconut samples.

The significant difference in the reducing sugar content of dehydrated coconut was observed between treatments, packaging methods and storage period. The osmotic dehydrated coconut pieces showed an increasing trend in the reducing sugar content from 6.59 to 9.51 per cent after 90 days of storage (Vennila and Pappiah, 1998) [14]. Similar observations were noticed in the present investigation too.

Table 3: Changes in reducing sugar (%) content of osmotic dehydrated coconut during storage

Storage period (days)	Control (T_0)		Treatments			
			10° Brix (T_1)		20° Brix (T_2)	
	Aerobic (P_1)	Vacuum (P_2)	Aerobic (P_1)	Vacuum (P_2)	Aerobic (P_1)	Vacuum (P_2)
0	4.40	4.40	7.05	7.05	7.88	7.88
30	4.53	4.62	7.46	7.40	8.21	8.14
60	4.98	4.84	7.87	7.81	8.79	8.70
90	5.27	5.33	8.19	8.05	9.04	8.92
120	6.10	5.72	8.90	8.64	9.63	9.54
150	6.93	6.05	9.38	9.01	9.96	9.89
180	7.14	6.27	10.15	9.76	10.44	10.35

CD ($P \leq 0.05$) Between Treatment (T) = 0.047, Packaging method (P) = 0.039, (T X P) = 0.067, Storage period (S) = 0.072, (T X S) = 0.125, (P X S) = 0.102and (T X P X S) = 0.177

Free fatty acid content changes during storage

The free fatty acid content of T_1 and T_2 was found to be lesser than the control sample. The control samples showed a drastic change in their free fatty acid content at the end of the storage in both the packaging method (table 4). The samples T_1 and T_2 packed at aerobic had slightly higher free fatty acid than the samples packed at vacuum condition. The free fatty acid content of aerobic packaged dehydrated coconuts T_0, T_1, and T_3 were between the range of 0.410 to 1.186, 0.404 to 0.564 and 0.394 to 0.523 per cent, respectively, whereas the value of vacuum packaged samples were ranged between 0.410 to 1.141, 0.404 to 0.538 and 0.394 to 0.498 per cent, respectively. The amount of free fatty acid content increased during storage of vacuum packaged dehydrated samples are slightly lower than the aerobic packaged samples. The statistical analysis showed that a significant difference in the free fatty acid content of the dehydrated coconut was seen between treatments, storage conditions, packaging methods and storage period.

Vennila and Pappiah (1998) [14] reported that the osmotically dehydrated control coconut pieces had higher free fatty acid (1.08% of oleic acid) content than the treated one (0.56% of oleic acid) after storing for 90 days. Similar situations were noted in the present study.

The fresh treated coconut grating stored for six months at ambient condition had increased the free fatty acid content from 0.26 to 1.56 per cent of oleic acid (Jayaraman *et al.*, 1998). The test sample selected for the study also exhibited an increase in the free fatty acid during storage.

Table 4: Changes in free fatty acid (% of oleic acid) content of osmotic dehydrated coconut during storage

Storage period (days)	Control (T_0)		Treatments			
			10° Brix (T_1)		20° Brix (T_2)	
	Aerobic (P_1)	Vacuum (P_2)	Aerobic (P_1)	Vacuum (P_2)	Aerobic (P_1)	Vacuum (P_2)
0	0.410	0.410	0.404	0.404	0.394	0.394
30	0.524	0.517	0.421	0.418	0.411	0.410
60	0.741	0.735	0.459	0.437	0.428	0.422
90	0.879	0.869	0.478	0.464	0.450	0.447
120	0.983	0.950	0.497	0.480	0.476	0.465
150	1.114	1.107	0.529	0.503	0.492	0.480
180	1.186	1.141	0.564	0.538	0.523	0.498

CD ($P \leq 0.05$) Between Treatment (T) = 0.005, Packaging method (P) = 0.004, (T X P) = N.S, Storage period (S) = 0.007, (T X S) = 0.012, (P X S) = 0.010 and (T X P X S) = N.S

Peroxide value changes during storage

The data collected on the peroxide value of the treated osmotic dehydrated coconut samples is given in table 5. Similar to free fatty acid, the peroxide value also increased as the storage period increases. The control sample exhibited a drastic increase in its peroxide value at the end of the storage than T_1 and T_2. A slight variation in the peroxide value was observed between treatment and packaging methods.

The control sample had maintained higher level peroxide value than the sample treated with 10°Bx and 20° Bx between 0 and 180 days of storage. A gradual increase in the peroxide value was noted in all the samples irrespective of packaging methods and treatments. Initially T_0, T_1 and T_2 contained 4.52, 4.45 and 4.38 per cent of peroxide value, respectively. At the end of the storage, the values were increased between the range of 8.34 to 7.46 (control), 5.79 to 5.32 (T_1) and 5.19 to 5.07 (T_2) per cent. This study shows that increase in peroxide value during storage is higher in aerobic packaged samples than the vacuum packaged samples. The statistical analysis of the data revealed a significant difference in the peroxide value of osmotic dehydrated coconut among various treatments, packaging methods and storage period.

Jayaraman *et al.* (1998) [3] reported that the treated preserved fresh coconut gratings showed an increase in the peroxide value from 3.1 to 15.5 mEq/kg after six months of storage. In the present investigation increase in the peroxide value was observed in the stored dehydrated coconut whereas the values obtained were found to be lesser than the reported value.

Table 5: Changes in the peroxide value (mEq/kg) of osmotic dehydrated coconut during storage

Storage period (days)	Control (T_0)		Treatments			
			10° Brix (T_1)		20° Brix (T_2)	
	Aerobic (P_1)	Vacuum (P_2)	Aerobic (P_1)	Vacuum (P_2)	Aerobic (P_1)	Vacuum (P_2)
0	4.52	4.52	4.45	4.45	4.38	4.38
30	4.73	4.64	4.52	4.50	4.45	4.43
60	5.54	5.15	4.84	4.69	4.59	4.51
90	5.90	5.43	5.03	4.88	4.73	4.68
120	6.31	5.90	5.28	5.02	4.92	4.77
150	7.15	6.59	5.46	5.19	5.08	4.86
180	8.34	7.46	5.79	5.32	5.19	5.07

CD ($P \leq 0.05$) Between Treatment (T) = 0.038, Packaging method (P) = 0.031, (T X P) = 0.053, Storage period (S) = 0.058, (T X S) = 0.100, (P X S) = 0.082 and (T X P X S) = 0.141

Microbial changes during storage

As the storage period progresses an increase in the microbial load was also noted (Table 6). The bacterial count of the samples was found to be more during storage when compared to fungi and actinomycetes. The control sample had higher microbial population than T_1 and T_2 packed in both the aerobic and vacuum condition. Initially the control sample had 7.0 x 10^6/g of bacteria, which had increased to 29.0 (aerobic), and 21.0 x 10^6/g (vacuum packaged). The samples T_1 and T_2 initially had 4.0 x 10^6/g of bacteria which showed an increase of 6.0 and 5.0 x 10^6/g at the end of the storage. The control sample initially had 4.0 x 10^2/g of fungi, which had increased to 11.0 (aerobic), and 8.0 x 10^2/g (vacuum) in after 180 days. The samples T_1 and T_2 did not show any increase in the fungal population during the study period stored in both the packaging methods. The actinomycetes level of control was 6.0 x 10^3/g, which had increased to 13.0 (aerobic), and 10.0 x 10^3/g (vacuum) after 180 days. Initially the samples T_1 and T_2 had 2.0 and 1.0 x 10^3/g of actinomycetes, respectively. The both aerobic and vacuum packaged 20° brix sugar solution treated sample shows the increase in actinomycetes level from 2.0 to 3.0 x 10^3/g. The result revealed that the osmotic dehydrated coconut treated with sugar solution and vacuum packed are contains less microbial population the aerobic packed samples.

Vennila (2003) [13] reported that the microbial population of the control and treated dehydrated coconut sample had increased during the study period (90 days). The initial bacterial level of control was noted as 128.0 x 10^6/g and 4.0 x 10^3/g for fungi and 4.0 x 10^3/g for actinomycetes which had increased to 152.0 x 10^6/g, 6.0 x 10^3/g and 8.0 x 10^3/g respectively. In the present study the increase in the microbial population was lesser than the levels reported by Vennila (2003) [13].

Table 6: Microbial changes in osmotic dehydrated coconut during storage

Treatments	Storage period	Bacteria (x10^6/g)		Fungi (x10^2/g)		Actinomycetes (x10^3/g)	
		Aerobic (P_1)	vacuum (P_2)	Aerobic (P_1)	vacuum (P_2)	Aerobic (P_1)	vacuum (P_2)
Control (T_0)	Initial	7.0	7.0	4.0	4.0	6.0	6.0
	Final	29.0	21.0	11.0	8.0	13.0	10.0
10^0 Brix (T_2)	Initial	4.0	4.0	1.0	1.0	2.0	2.0
	Final	6.0	5.0	1.0	1.0	2.0	3.0
20^0 Brix (T_2)	Initial	4.0	4.0	2.0	1.0	2.0	2.0
	Final	5.0	5.0	4.0	1.0	3.0	3.0
CD ($P \leq 0.05$)	Treatment (T)	0.087		0.049		0.089	
	Packaging method (P)	0.087		0.049		0.089	
	T X P	0.123		0.069		0.126	
	Storage period	0.107		0.060		0.109	
	TXS	0.151		0.084		0.154	
	PXS	0.151		0.084		0.154	
	TXPXS	0.213		0.119		0.218	

Conclusion

The osmotic dehydrated coconut treated with sugar solution along with vacuum packaging prevent the oxidation of fat present in the coconut during storage. So, it reduce the formation of free fatty acid and peroxide value of the dehydrated coconut. It helps in the prevention of rancidity of the products. Osmotic treatment and vacuum packaging hinder the growth of microorganism such as bacteria, fungi and actinomycetes. So, shelf life of the dehydrated coconut can be extended by osmotic dehydration vacuum packaging.

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